Chapter 9

Herpetofauna of Montane Areas of Tanzania. 5. Range Extension of *Phrynobatrachus sulfureogularis* (Anura, Phrynobatrachidae) from Burundi to the Mahale Mountains of Western Tanzania with a Redescription of the Species

Lucinda P. Lawson[1] and Breda Zimkus[2]

[1]*Department of Zoology, Field Museum of Natural History, 1400 South Lake Shore Drive, Chicago, IL 60605, USA*
[2]*Museum of Comparative Zoology, Harvard University, Cambridge, MA 02138, USA*

Abstract

Two large forest *Phrynobatrachus* (male, snout–urostyle length 42.2 mm; subadult, snout–urostyle length 27.4 mm) were collected from the Mahale Mountains in Tanzania, exhibiting a large tympanum (55%–76% of the eye diameter), large digital discs, and a bright yellow throat in males. A comparison of these two individuals with all described *Phrynobatrachus* species was made, and they were found to fit the description of *P. sulfureogularis*, a poorly known species only known from the type locality in Burundi. This new population represents a substantial southern range extension or potentially a similar, yet undescribed species.

Introduction

Phrynobatrachus sulfureogularis Laurent, 1951, is a large species (snout–vent length [SVL] up to 43 mm) of puddle frog, known previously only from the type locality in Nanzergwa, Burundi, at 2300–2500 m (Fig. 1). *Phrynobatrachus sulfureogularis* is characterized by its granular dorsum, moderate to extensive pedal webbing, and greatly expanded digital discs. Breeding males exhibit a yellow gular region and minute asperities, particularly on the posterior hind limbs and the latero-ventral part of toe V.

Two large *Phrynobatrachus* specimens (male, snout–urostyle length [SUL] = 42.2 mm; juvenile, SUL = 27.4 mm) were recently collected from Mahale Mountains (Fig. 1) in western Tanzania by W. Stanley (FMNH 275459 and 275460) that exhibited many of the morphological characteristics of *P. sulfureogularis*. Comparisons of the individuals from Mahale (*P.* cf. *sulfureogularis*) were made to other puddle frog species distributed in Tanzania, Burundi, Rwanda, and the eastern Democratic Republic of the Congo. The new specimens were then compared with the type series of *P. sulfureogularis* (by B.Z.) at the Royal Museum for Central Africa (Tervuren, Belgium) to determine whether the new collections were conspecific with the type series.

In the original description by Laurent (1951), the type specimen (female) was described, and the existence of 20 paratypes was recorded. The description lacked any morphometric data and was vague on many key details. *Phrynobatrachus sulfureogularis* is herewith redescribed and compared with specimens from the Mahale population.

Methods

Both individuals from the Mahale population of *P. sulfureogularis* were caught by hand along a small river 0.5 km northwest of Nkungwe Hill Summit, 6.10343°S, 29.77895°E, 2100 m, on 25 August 2003 (FMNH 275459) and 27 August 2003 (FMNH 275460) by W. Stanley. The Mahale specimens were collected incidentally, and neither detailed habitat nor call data were taken. Measurements taken on preserved specimens are SUL, head length (HDL), head width (HDW), width of the eye at its widest point (EYE), width of the interorbital space (IOS), width of the internarial space (INS), distance between the eye and the naris (ENS), distance between the naris and the tip of the snout (NS), distance between the naris and the edge of the upper lip (NLL), tibia–fibula length (TiL), femur length (FeL), tarsus length (TaL), distance between the inner and outer metatarsal tubercles (IOMT), width of the hand at its widest point (HaW), distance between the base of the hand and the tip of the third finger (FiL3), tympanum width (Tym), and length of the first toe (ToL1) and fourth toe (ToL4). Webbing formula reflects the extent of the main, broad web as opposed to the more variable thin fringe on the toes.

The type series from the Royal Museum for Central Africa (RMCA) was examined by B.Z., with particular focus on male specimens comparable to the specimens from Mahale. Paratype specimens were originally grouped within the series RMCA B.108822–108841 but not assigned individual numbers. All those identified as mature males and females were assigned museum catalogue numbers RMCA B.108821

FIG. 1. Type locality of *P. sulfureogularis* (circle), new locality of *P.* cf. *sulfureogularis* (star), type locality of *P. krefftii* (square), and known distribution of *P. krefftii* (outlined area).

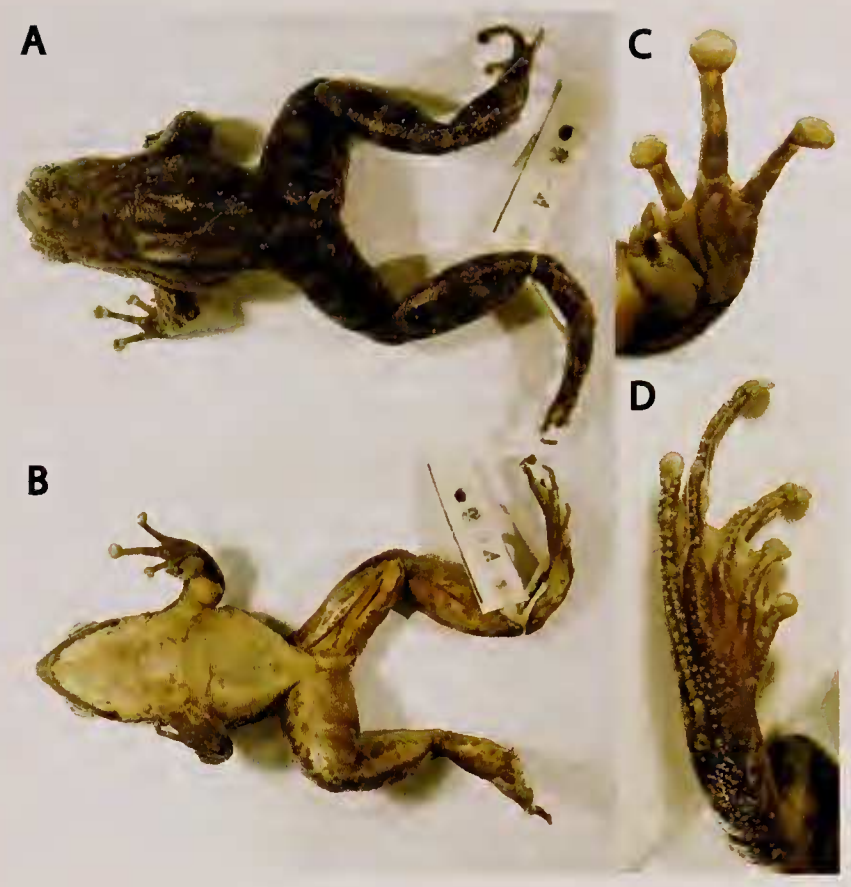

FIG. 2. Photographs of *P.* cf. *sulfureogularis* (FMNH 275460) from Mahale, Tanzania. Dorsal view (**A**), ventral view (**B**), detail of ventral side of hand, showing expanded digital discs and nuptial pad on the base of finger I (**C**), detail of ventral side of foot (**D**).

through RMCA B.108829. The female holotype and three breeding males were subsequently photographed and measured (female type = RMCA B.108821, male paratypes = RMCA B.108822, RMCA B.108823, and RMCA B.108824) as described above. In addition to those specimens that had complete morphometric data measured, SUL data were obtained from five additional mature males and one female to determine the overall size range within the series.

Results

Description of Specimens (*P.* cf. *sulfureogularis*) from Mahale

Measurements from representatives of the Burundi type series and the Mahale series are displayed in Table 1. Only one of the two Mahale specimens (both male) appears to be an adult, with a SUL of 42.2 mm. The snout is elongated, sharp, and noticeably overhangs the lower jaw; a small, oval papilla present on the tongue; canthus rostralis rounded; tympanum is large, round, and approximately 75% the size of the eye; minimal supratympanic ridge; eye width is greater than tympanum diameter and greater than the interobital space; eyes have horizontal pupils that are visible from below; manual webbing absent; internarial distance is equal or less than the interorbital distance; round nostrils visible from above; nostrils closer to the snout tip than the eye and have a slightly raised ridge on outside; tibia is approximately 50% of the snout–vent length; femur is approximately 50% of the snout–vent length; tibio-tarsal articulation reaches the eye; finger and toe tips are expanded into large discs (Fig. 2); manual webbing is absent; subarticular tubercles are well defined; second finger is longer than the first; third finger is 28% of the snout–vent length; inner metatarsal tubercle oval-shaped; outer metatarsal and tarsal tubercles round; toe-webbing formula: 1 (disc), 2i (1st), 2e (disc), 3i (1.75), 3e (2nd), 4i (2nd), 4e (2nd), 5 (1.5); dorsal skin very finely granular with small, round asperities on the lower back and legs; two oblique glandular folds often present in the scapular region of the dorsum, followed in the lumbar area by a semi-circular fold with posterior concavity that is sometimes broken; femoral glands absent; gular sac with lateral vocal folds running parallel to the jaw line; minute spinules present in males, particularly on the posterior limbs and the lateroventral part of toe V. Dorsal and ventral views, along with details of the foot and hand, are shown in Figure 2.

Dorsal coloration dark brown with darker speckles; glandular folds often darker; ventral surface light in color (in alcohol), throat in males bright yellow in life (Fig. 3). Light speckling across pectoral region; upper jaw mottled; indistinct light eye-to-arm band present above the tympanum; anterior surface of the thigh and posterior surface of the tibia banded; posterior surface of the thigh speckled or banded.

Redescription of *P. sulfureogularis*

Phrynobatrachus sulfureogularis was first described by Laurent (1951), based on a type series collected from the Nanzergwa Massif in Burundi (2300–2500 m, −3.4°S, 29.5°E). The type series is the only known collection of *P. sulfureogularis* and is housed in the RMCA Tervuren, Belgium. This species appears to have escaped further scientific inquiry until the present study.

Laurent (1951) described *P. sulfureogularis* as an exceptionally large *Plurynobatrachus* with a distinctive yellow vocal sac. The following three paragraphs are a translation from the type description, confirmed by examination of the type series by Zimkus.

Specimens of *P. sulfureogularis* possess both a distinct canthus rostralis and a slightly concave frenal region. Toes are

TABLE 1. Measurements (in mm) of two specimens of *Phrynobatrachus* cf. *sulfureogularis* (male and juvenile: Mahale, Tanzania), type specimen of *P. sulfureogularis* (female: Burundi), and two paratypes (males: Burundi).

	Mahale (male) FMNH 275460	Mahale (juvenile) FMNH 275459	Holotype (female) RMCA B108821	Paratype (male) RMCA B108822	Paratype (male) RMCA B108823	Paratype (male) RMCA B108824
SUL	42.2	27.4	42.2	40.4	38.3	36.8
HDL	14.6	10.3	16.9	15.2	16.0	13.5
HDW	13.5	9.6	14.4	12.6	13.4	12.9
EYE	4.65	3.6	5.4	5.6	4.9	5.2
IOS	3.9	2.8	4.1	4.6	4.0	3.9
INS	3.9	2.7	3.9	3.9	3.7	3.8
ENS	3.2	2.3	3.4	3.0	2.9	2.5
NS	2.2	1.7	1.5	1.7	2.2	2.1
NLL	2.6	1.8	2.6	2.6	2.4	1.9
TiL	20.7	13.8	21.1	22.5	22.0	20.1
FeL	21.0	12.6	18.8	20.1	19.5	17.6
TaL	11.1	6.8	—	—	—	—
IOMT	2.1	1.7	2.0	2.3	2.6	2.1
ToL4	21.3	13.7	17.6	18.5	18.0	—
ToL1	7.1	6.2	5.1	6.0	5.4	—
HaW	4.6	3.2	5.0	6.0	4.8	4.9
FiL3	11.7	7.4	13.3	12.3	11.6	10.2
Tym	3.5	2.0	3.2	3.9	3.5	3.5

two-thirds webbed, deeply penetrating the webbing between the metatarsals, and sub-articular tubercles are prominent. The tibio-tarsal articulation reaches the eye. The skin is finely granular with spiny dorsal-lateral folds in males. In many specimens from the type series, two converging oblique glandular folds extend to the shoulder region, followed in the lumbar region by a semi-circle concave posterior fold.

The dorsal coloration is brownish, blackish olive, and speckled with a darker flecks. The glandular folds are sometimes darker than the surrounding skin. Transverse bands are distinct on the anterior thighs and shins, in a low proportion of specimens (both male and female: 3/20). In some specimens, two clear dorsolateral stripes are present, similar to those often observed in *P. acutirostris*, *P. versicolor,* and *P. dendrobates*.

The ventral surface is cream with diffuse darker pigmentation around the legs and throat in females. In males, legs and chest are distinctly darkly pigmented, creating a sharp contrast to the rest of the ventral surface. The vocal sac of the male is bright sulfur-yellow with lateral folds. The spiny tubercles of the male are particularly numerous on the hind limbs and the ventral lateral part of the fifth toe.

In addition to translating the type description (presented above), we measured a number of paratypes and recorded traits not mentioned in the original (measurements in Table 1). The conical papilla in the middle of the tongue is large and distinct. The snout is more rounded in some (e.g., males RMCA 108822, 108824) and pointed in others (e.g., males RMCA 108823), always distinctly overhanging the lower jaw. The tympanum is distinct and smaller than the eye width. Specimens possess a glandular fold starting behind the eye, passing over the tympanum and extending to the birth of the forelimb. Nostrils are slightly closer to the end of the snout than to the eye, although variable. In addition to the female holotype, for which the SVL

FIG. 3. Photographs of *Phrynobatrachus krefftii* (**A**) and *P.* cf. *sulfureogularis* (**B**) males in life, illustrating bright yellow throat. *Phrynobatrachus krefftii* photo by D. L. Mahler and B. Zimkus; *P.* cf. *sulfureogularis* Mahale specimen photo by W. Stanley.

measured 42.2 mm, the largest female paratype measured 43.6 mm. Males from Burundi had a maximum SVL of 42.6 mm (n = 8).

From the morphological comparison of the new specimens (measurements in Table 1) to the type series, we believe that the population of large-bodied, yellow-throated *Phrynobatrachus* from Mahale cannot be definitively excluded from *P. sulfureogularis* based on any trait described above. Because of the high rate of endemism seen in this area, the isolation between the localities, and the limited sample size of the new population, we will refer to this population as *P.* cf. *sulfureogularis* until larger sample sizes, call data, and molecular data are available to clarify these relationships. The new population can be easily distinguished from all other *Phrynobatrachus* species, however. Because both share the traits described below, we collectively refer to them as *P. sulfureogularis* in comparisons.

Comparisons

The large size of *P. sulfureogularis* distinguishes this puddle frog from most of the species of the genus, and a number of additional morphological characteristics also reveal the distinctness of this form. The clearly visible and large tympanum, as well as the large size, distinguish it from a number of species distributed in Burundi and Tanzania, including *P. acridoides, P. breviceps, P. keniensis, P. mababiensis, P. pakenhami, P. pallidus, P. parvulus, P. rouxi, P. rungwensis, P. scheffleri, P. stewartae, P. ukingensis, P. ungujae,* and *P. uzungwensis.* The tympanum of *P. perpalmatus* is only feebly distinct, and this small species (SVL < 29 mm) exhibits only slightly swollen digit tips. *Phrynobatrachus bullans* exhibits a visible tympanum and moderate webbing on the toes but lacks digital discs, has a grey or brown dorsum, and is significantly smaller (SVL < 28 mm) than *P. sulfureogularis.* The tympanum may or may not be visible in *P. natalensis*, which also exhibits pedal moderate webbing, but this species is also significantly smaller in size (SVL < 31 mm) when compared with *P. sulfureogularis.* A distinct tympanum and moderate pedal webbing characterize *Phrynobatrachus bequaerti*, but digit tips are only slightly expanded, and size is significantly smaller (SVL < 25 mm).

Phrynobatrachus sulfureogularis is morphologically most similar to *P. acutirostris, P. asper, P. dendrobates*, *P. irangi*, *P. petropedetoides*, *P. versicolor*, and *P. krefftii. Phrynobatrachus acutirostris* differs from *P. sulfureogularis* by its conical rather than oval papilla on the tongue, eye length less than interorbital space, smaller digital discs, smooth as opposed to granular skin, and venter that is mottled, speckled, or dotted, often with a longitudinal band running through the throat and breast. *Phrynobatrachus asper* differs from *P. sulfureogularis* by its blunt digital tips and absence of discs, numerous longitudinal folds and rows of warts and tubercles on the dorsum, and extensive pedal webbing with between one and two phalanges free on toe IV (compared with *P. sulfureogularis* with two phalanges free on toe IV). The eye to nostril distance is also greater than nostril to snout distance in *P. sulfureogularis* (1.45–1.35 mm), whereas the nostril is located midway between the eye and the tip of the snout in *P. asper. Phrynobatrachus dendrobates* and *P. petropedetoides* can be easily distinguished from *P. sulfureogularis* by their blunter snouts (compared with the protruding and sharply pointed profile of *P. sulfureogularis*), conical rather than oval papillae on the tongue, less extensive pedal webbing with three phalanges free on toe IV, and eye width greater than interorbital space. *Phrynobatrachus irangi* differs from *P. sulfureogularis* by its moderate webbing with three phalanges free on toe IV, digital tips that are rounded and only slightly dilated, and a gular region that is somewhat grayish. *Phrynobatrachus versicolor* differs from *P. sulfureogularis* because toe discs are less developed in the former, a more or less distinct median line may be present on the venter, the interorbital space is broader than upper eyelid, and the nostril is located midway between the eye and the tip of the snout.

Only five species of *Phrynobatrachus* exhibit a bright yellow throat in breeding males: *P. sulfureogularis, P. krefftii, P. latifrons, P. minutus*, and *P. alleni. Phrynobatrachus alleni* and *P. latifrons*, found in West Africa, and *P. minutus*, found in Ethiopia, are all much smaller than *P. sulfureogularis* and the Mahale specimens (*P. alleni* males average 18.4 mm SUL [Rödel & Ernst, 2002], *P. latifrons* males average 14–20 mm [Rödel, 2000], and *P. minutus* males average 15–20 mm [Boulenger, 1895]). *Phrynobatrachus latifrons* and *P. minutus* both have small tympanums and lack true discs (Rödel, 2000), unlike *P. sulfureogularis* and the Mahale specimens.

Phrynobatrachus sulfureogularis is most notably similar to *P. krefftii*, particularly regarding its size and bright yellow throat in breeding males (Fig. 3). Snout–vent lengths of *P. krefftii* range from 36 to 46 mm (n = 14) in males and 45 to 51 mm (n = 4) in females (Drewes & Perret, 2000). Many additional characteristics are similar, including similar dorsal and ventral markings (light and dark brown mottling on the dorsal and lateral surfaces, light and dark brown banding on the hind legs, and light lines on the fingers at the base of the expanded disks), large expanded disks on fingers and toes, and presence of thickened nuptial pads on base of finger I in males. Extent of pedal webbing is similar between the two species with one or two phalanges free on toe IV (Channing & Howell, 2006; Pickersgill, 2007), and the tympanum is 75% of eye width in *P. sulfureogularis*, within the 60%–80% range in *P. krefftii.* A number of characteristics differentiate *P. krefftii* from *P. sulfureogularis*; a conical rather than oval papilla is present on the tongue of the former, interorbital space as broad as the upper eyelid (compared with eye width that is greater than interobital space in *P. sulfureogularis*), toe discs are smaller and often have a terminal point in *P. krefftii* when compared with *P. sulfureogularis*, and lack of asperities on the plantar surface of the foot, although plantar spines are present on the toes. Although similar, it appears that the overall shape of *P. sulfureogularis* is different from *P. krefftii* (measurement for *P. krefftii* from Pickersgill, 2007); head width/SVL = 32%, slightly smaller than the 34%–40% (mean 37%) for *P. krefftii*; tibia/SVL = 49%, compared with the 50%–55% (mean 52%) for *P. krefftii*: head width/tibia = 65%, compared with 68%–75% (mean 71%) in *P. krefftii.*

Phrynobatrachus krefftii is known from the Eastern Arc Mountains of Tanzania, specifically from the East and West Usambara Mountains (Fig. 1). Descriptions for comparisons were taken from Boulenger (1919), De Witte (1941), Laurent (1941, 1951, 1972), Grandison and Howell (1983), Poynton and Broadley (1985), Drewes and Perret (2000), Rödel (2000), Rödel & Ernst (2002), Crutsinger et al. (2004), Hirschmann and Hödl (2006), and Pickersgill (2007).

Discussion

Species delimitation of African herpetofauna can be a difficult task, confounded by vague type descriptions, absence of molecular data for type specimens, and generally poor sampling. It was difficult initially to identify *P.* cf. *sulfureogularis* collected from Mahale National Park in Tanzania as being previously described or distinct and new due to lack of documentation on *P. sulfureogularis*. For example, *P. sulfureogularis* is not mentioned among the yellow-throated *Phrynobatrachus* in Hirschmann and Hödl's (2006) recent study, and this information was only available in the original description by Laurent (1951). Although morphologically similar to the type series of *P. sulfureogularis*, the taxonomic distinctiveness of the populations of *P.* cf. *sulfureogularis* should be assessed in the future. This aspect is highlighted because of the distance of approximately 300 km between Tanzanian and Burundi populations and the distinctiveness of mountain assemblages and high rates of endemism across this region (Fjeldså, 2003). Examination and description of live specimens, including call recordings, DNA analysis, and ecological information of both populations is necessary to clarify the relationship between *P. sulfureogularis and P.* cf. *sulfureogularis,* and between these and other *Phrynobatrachus* species. No genetic data currently exist for *P. sulfureogularis*, but due to appearance and geographic distribution, Zimkus et al. (2010) hypothesize that this species would fall within the clade known to contain *P. krefftii* and the Albertine Rift species *P. acutirostis*, *P. dendrobates, P. petropedetoides*, and *P. versicolor*. Obtaining information from both the type locality and the Mahale population will help to resolve these relationships.

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